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ON THE SAURODONTIDÆ.

BY EDWARD D. COPE, A. M.

Read before the American Philosophical Society, November 18th, 1870.

The genus *Saurocephalus* of Harlan and its allies have been referred to the neighborhood of the Acanthopterygian family of the *Sphyrænida* by Prof. Agassiz in his *Poissons Fossiles*, after having been regarded by Harlan and Hays as reptilian. This was an important step in the right expression of its affinities; but I take the present opportunity of making another progress in the true interpretation of its relations, favored as I am by the opportunity of examining new material not accessible to former authors. My conclusion, it will be observed, differs widely from that heretofore maintained.

Some years after Harlan's description of *Saurocephalus lanciformis* appeared, Dr. Hays described a second species under the name of *Saurodon leanus*. This I believe to represent a genus distinct from the former. A third genus more remote is characterized in the present article.

The characters of first importance which may be assigned to these genera are :—

Vertebræ short, numerous; their neural arches united with centrum by persistent suture. Tail vertebrated or heterocercal. Superior arch of the mouth formed by the short premaxillaries and long maxillaries. Teeth one-rowed, with fangs received into alveoli more or less confluent at their openings. Anal or caudal radii with complex segmentation.

These characters are most of them entirely contradictory of any affinity to the *Sphyrænida*, those presented by the vertebræ indicating a nearer approach to *Amia*. The structure of the mouth is not that of any Acanthopterygian fish, and with the complex segmentation of some of the radii approaches nearer such types as the *Characinida*. The form of the vertebral centra is utterly different from that of the *Sphyrænida*: in the *Saurodontida* they are short, little contracted medially, and deeply grooved on the sides; in the *Sphyrænida*, elongate, much contracted, and exceptional among Teleosts in being smooth and grooveless!

The characters presented by the teeth and vertebræ of *Saurocephalus* remind one much of *Serrasalmo*, though the genus is no doubt in other respects widely removed from that group. On the characters above enumerated, I propose the family *Saurodontida*. Its precise position I am not prepared to determine at present, though I have little doubt that *Amia* is its nearest living ally. With the remains of species of this group occur numerous scales, which may belong to the former. They are cycloid and without ganoine.

The three genera are distinguished by the form of their jaws and teeth: in *Saurocephalus* the crowns are shortened, much compressed, and with sharp edges; in *Saurodon* the crowns are elongate, subcylindric and slightly curved near the apex. In *Ichthyodectes* the teeth are similar

to those of *Saurodon*; but the margins of both jaws are without the large foramina so prominent in both the other genera. There appear to be some important differences also in the vertebræ, which will be mentioned below.

In the Transactions of the American Philosophical Society for 1856, Dr. Leidy treats *Saurocephalus* as a Sphyrænoid fish, and regards *Saurodon* as a synonyme. He corrects the erroneous references of some European authors, showing the *Saurocephalus* of Dixon to be a *Xiphias*, and the *Saurodon* of Agassiz to be some other genus which he calls *Cimolichthys*, without characterizing it. This form is supposed to be established on palatine teeth, and if so, is well distinguished, as it will be seen below, that *Saurocephalus* has no teeth on the palatine bones. He also refers two other species of supposed *Saurocephalus* of Agassiz to a new genus called *Protosphyræna*, without characters. This I think rests on mandibular teeth of true *Saurocephali*.

SAUROCEPHALUS. Harlan.

Journ. Acad. Nat. Sci. Phila. III. 337. *Xiphactinus* Leidy Proc. Ac. Nat. Sci. Phil. 1870. 12.

SAUROCEPHALUS LANCIFORMIS. Harlan l. c.

Med. and Phys. Researches, 362. Leidy Trans. Amer. Philos. Soc. 1856. Tab. *Saurodon lanciformis*, Hays Trans. Amer. Philos. Soc. 1830, 476.

Established on a right superior maxillary bone from a locality near the Missouri river. It differs from that of the other species in having a very elongate superior suture with the premaxillary bone, and in the very short dental crowns, which are as wide as deep. The largest species; known from the jaw.

SAUROCEPHALUS PHLEBOTOMUS. Cope sp. nov.

Established on some vertebræ and portions of the cranium, the latter including the dentary, maxillary, part of the premaxillary, the palatine and vomerine bones, compressed into a mass by pressure, the separate pieces preserving nearly their normal relations. From the latter the following characters may be derived:

Palatine bones toothless; teeth of both maxillary and dentary, with compressed crowns, which are longer than wide at base, and closely placed, those of the dentary twice as large as those of the maxillary. Maxillary bone proximally deep; dentary shallower, the maxillary with elongate suture with the premaxillary behind.

The teeth are equilateral, without intermarginal groove or barb, and with smooth enamel surface, or only minutely striate under the microscope. A series of larger foramina extends along the alveolar margin of the maxillary and dentary bones, one foramen to each tooth. The alveolæ are confluent as they approach this margin.

There are three vertebræ, which present two pairs of deep longitudinal grooves, viz.: two on each side, two on the inferior, and two on the supe-

rior face of the bone ; the last receives the basal articulation of the hæmaphysæ. The centra are crushed, their measurements with those of the jaws are as follows :

	M
Length centrum.....	0.025
Long diameter (crushed).....	.035
Short " ".....	.0175
Depth maxillary bone anteriorly.....	.031
Depth dentary " ".....	.015
Length crown inferior tooth.....	.006
Number " " " in .01m.....	3
" " superior " ".....	4.5
Length crown " " ".....	.0046

The vertebræ are about as large as those of a fully grown "drum fish," *Pogonias*.

From the yellow chalk of the upper Cretaceous of Kansas, found on the Solomon or Nepaholla River, Kansas, at a point 160 miles above its mouth, by Professor B. F. Mudge, Professor of Natural Science in the State Agricultural College of Kansas.

I append a description of some caudal vertebræ of a species probably different from the *S. phlebotomus*. It is indicated by three consecutive caudal vertebræ which resemble those of *S. prognathus* and *S. thaumas*, but which differ also considerably from both ; the several arches and spines are of very great width : in *S. thaumas* they are narrow, and in *S. prognathus*, as wide, but here their width exceeds the depth and equals the length of the centrum. As in the other caudals, the lateral grooves are wanting and the inferior pair remain separated by a lamina. The neural suture is very distinct, and not two angled as in *S. prognathus*, but with a median decurvature and rise anteriorly. The neural spines are twice as wide as deep and lie on each other. The third vertebra is shorter than the others and contracted distally ; it is probably the penultimate of the series ; neural canal minute. Surface striate ridged.

Measurements.	M.
Length centrum anterior vertebra.....	0.021
Depth " (at middle) anterior vertebra.....	.015
Width neural arch at base spine.....	.010
Depth spine.....	.0072
Length third vertebra.....	.0135
Width neural arch.....	.014
" " spine.....	.0176

From a point twenty miles east of Fort Wallace, Kansas. Professor Mudge's collection.

In this species the vertebræ in question are longer in proportion to their other dimensions than in those described, besides carrying wider neural arches and spines.

SAUROCEPHALUS PROGNOTHUS. Cope *sp. nov.*

This species is represented by a premaxillary and attached proximal portion of the maxillary bones of the right side, and by a large number of vertebræ and other bones. These portions were associated in the collections placed in my hands by Prof. Mudge, and relate to each other in size, as do those of the preceding species and the *Ichthyodectes etenodon*.

The premaxillary is characterized by its great depth as compared with its length, and by the shortness of its union with the maxillary. The palatine condyle of the maxillary reaches a point above the middle of the alveolar margin of the premaxillary. The latter contains alveolæ of seven teeth, the anterior of which only presents a perfect crown. This is still more elongate than the crown of the teeth of *S. phlebotomus*. It is compressed, equilateral, smooth, and acute. Its direction is even more obliquely forward than the anterior outline of the bone, which itself makes an angle of 50° with the alveolar border.

The vertebræ consist of cervicals, dorsals, and caudals, to the number of about sixty, most of which are supposed to have been derived from the same animal. The grooves are as in *S. phlebotomus*, there being two below, two on each side, and two above. The latter receives the bases of the neurapophyses, which are in many cases preserved. The inferior pair of grooves becomes more widely separated as we approach the cervical series, leaving an inferior plane, which is longitudinally striate grooved. This plane widens till the grooves bounding it disappear. The inferior lateral groove becomes widened into a pit which some of the specimens show to have been occupied by a plug-like parapophysis, as in *Elops*, etc., or a rib-head of similar form. The neurapophysial articular grooves become pits anteriorly, and these only of all the grooves, remain on the anterior two vertebra in the collection. Some of the posterior caudals preserve large portions of the neural arches and spines. They form an oblique zigzag suture with the body, consisting of two right angles, one projecting upward anteriorly another downward behind. The neural spines are very wide and massive and in close contact antero-posteriorly; these probably support the caudal fin. They are deeply and elegantly grooved from the basis upwards. The centra exhibit no lateral grooves.

An unsymmetrical fin ray accompanied these remains, and from its mineralization, color, size, and sculpture, probably belongs to them. The anterior margin is thinned, and with obtuse denticulations, the posterior truncate. The section is lenticular, with a deep rabbet on one side of the posterior edge; section at the base, apex circular lost. The sculpture consists of fine longitudinal raised striæ, which bifurcate and send numerous similar ridges to the teeth of the anterior margin. It is probably a spine of a pectoral fin. It is identical in form and sculpture with that recently described by Leidy as *Xiphactinus audax*, but differs in specific details.

	M
Long diameter of spine.....	0.0245
Basal " "019
Length, two cervicals (not distorted).....	.033
Diameter of the anterior.....	.021
Length of a dorsal.....	.016
" " caudal.....	.014
Width neural spine of caudal, at base.....	.012
Length alveolar margin premaxillary.....	.022
" anterior " "02
Depth from condyle of maxillary.....	.026
Length crown premaxillary tooth.....	.0042
Diameter " " "002

A fragment of a large flat bone exhibits very delicate radiating grooves which are marked by spaced impressed dots.

From the upper Cretaceous of Kansas, six miles south of the town of Sheridan. Prof. B. F. Mudge. This species was about two thirds the size of the species last described.

SAUROCEPHALUS AUDAX. Leidy, sp.

Xiphactinus audax. Leidy. Proc. A. N. Sci. Phil. 1870, 12.

Established on a pectoral spine, supposed by Leidy to be that of a Siluroid. According to the description, it does not differ from that of *S. prognathus* in more than specific characters. Thus the anterior margin is weakly serrate in the latter, a feature not described by Leidy in the former. In *S. audax* the posterior portions of both sides are said to be grooved; in that part of the spine of *S. prognathus* preserved, one surface only exhibits the groove in question, one of whose edges is obliquely ridged, as in *S. audax*. From Kansas; museum Smithsonian.

SAUROCEPHALUS THAUMAS. Cope sp. nov.

This is larger than any of the species here described. It is represented by wholes or parts of from seventy to eighty vertebræ, with numerous neural and hæmal spines and fin radii, and perhaps some ribs. There are no teeth nor cranial fragments. The bulk of the vertebræ is double that of those of *S. phlebotomus*, and appropriate to an animal of the size of the *S. lanciformis*. It may be ultimately found to be identical with that species; but there is no evidence conclusive of such a view at present in my possession.

The vertebræ present the usual two inferior, two lateral, and two superior grooves—the last for the neural arch. There are no cervical vertebræ, for these characters show them all to be dorsals and caudals. The suture for the neurapophyses forms a regular angulate convexity projecting downwards. The arch is not closed above anteriorly, and is expanded laterally, while the spine is directed very obliquely backwards. The concavities of the articular extremities are equal in the dorsals; but in the caudals one surface is much more deeply concave than the other, one being funnel-shaped, and the other nearly plane in a few.

A number of consecutive vertebræ are preserved, which represent the posterior portion of the caudal series. One of these is fortunately the very extremity, and they demonstrate the tail to have been vertebrated or heterocercal, after the manner of *Amia*. On the anterior series of three the lateral grooves have disappeared from the centra; the neural canal is very small, and the spines are very massive and curved backwards, but much less than in the more posterior parts of the column; they are flattened, wider than deep, and in close contact with each other. The anterior of the three, on the other hand, presents a narrowed edge forwards. The hæmapophyses are thin, and suturally united by a flat gomphosis. The terminal series embraces six vertebræ, which have a minute or obsolete neural canal, but hæmal canal distinct, but apparently interrupted. The hæmal arches are united to the centra by a rather smooth suture.

The general direction of these vertebræ forms a light upward curve. The hæmal spines are flat and laminar, and their margins in contact; they decrease in width and length to the end of the series. The neural spine lies obliquely backwards, and has a narrowed anterior ridge, but stout shaft.

The anterior hæmal spine in place exhibits a subglobular base, like an articulation, and its shaft is wider than those posterior to it. A subtriangular flat bone, with neck and subglobular extremity, applies very well to a concavity between the anterior pair of pleurapophyses, but does not in that position preserve contact with the anterior margin of the second spine. One margin of the enigmatical bone is thin and divergent; the other expanded laterally and straight. The latter gives off a transverse prominence like half a globular knob before reaching the extremity. Just within the latter are two large foramina, which are connected with the extremity by a groove on each side, which meet in a notch where the thin edge passes into the knob.

Both sides of the neural and hæmal spines are concealed in this species and in the *S. prognathus* by numerous parallel osseous rods, which are somewhat angulate in section. They lie along the centra of the anterior series of caudal vertebræ, but are not to be found on vertebræ of any other part of the column. Numerous loose and fragmentary rods of the same character accompany the loose and attached caudal vertebræ, and all of them, according to Prof. Mudge, belong to the "posterior swimming organ" of this animal. There is also a collection of these rods from the anterior region of the body, which Prof. Mudge thought occupied the position of an anterior limb. They do not any of them present a segmentation such as would be exhibited by the cartilaginous radii of caudal and pectoral fins, and their nature might have remained doubtful but for the explanation furnished by the anterior compound ray or spine of the posterior, probably caudal fin. This ray, as in the case of the pectoral spine and first anal rays of some existing Siluroid and Loricariid fishes, is composed of a number of parallel rods closely united. These

are in their distal portions remarkably and beautifully segmented, of which a very simple form has been figured by Kner, as existing in the pectoral spine of the Siluroid genus, *Pangasius*. This segmentation becomes more obscure proximally, and finally disappears altogether, leaving the spine and rods homogeneous. This portion of them is quite identical with the rods found in the positions of fins already described, and I therefore regard these as fin radii of the attenuated form presented by cartilaginous rays of most fishes, but ossified sufficiently to destroy the segmentation. They are thus in the condition of the anterior rays of the dorsal fin of some of the large Catostomidæ, where they are proximally homogeneous and bony, distally segmented and cartilaginous. This is an important character when found in pectoral and caudal fins, and such as I have not found described. It adds another feature to the definition of this group.

The segmentation above alluded to presents the following characters. The spine consists of four principal parallel rods, of which the external on each side thins, the one to an obtuse, the other to a thin edge. The more obtuse edge presents a groove on one side, which is occupied by a very slender rod, and a shallow rabbet along the flat edge is occupied by a slender flat rod. Of the four principal rods the two median are the most slender, and the flat marginal the widest. Of the two median, that next the last is the wider. The stout marginal, or probably anterior rod, is segmented en chevron, the angle directed forwards and lying near the free margin. The suture of the segments is entirely straight, except when returning it approaches the margin, where it suddenly turns to the margin at right angles to it. The next rod is segmented without chevron obliquely backwards and inwards; where it leaves and reaches the margins, it is at right angles to them, and the margin projects obtusely at those points. Between them the suture is very irregular and jagged, sending processes forwards and backwards. The segmentation of the next rod is similar, but more regularly serrate; distally it becomes as irregular as in the last. The transverse marginal termini of the sutures are serrate in both. The inner and widest rod presents a still more regularly serrate suture, with the truncate extremities; but, owing to the width of the rod, the near approximation of the sutures continues for a longer distance. When broken, the suture appears step-like,

This remarkably beautiful segmentation is paralleled remotely, as has been stated, by some Siluroids. Much more like the recent type are the segmented rays of the carboniferous genus, *Edestus* of Leidy, regarded variously by authors as a jaw or a ray; but now generally regarded as a ray.

<i>Measurements.</i>		<i>M.</i>
Length fragment of (?)caudal spine.....		0.25
Width " at proximal fracture.....		.06
Greatest thickness " "013
Width posterior rod " "0245
Length of six distal caudal vertebræ.....		.10

	<i>M.</i>
Width hæmal spine of second of series.....	.024
Vertical diameter centrum first "025
Length of neural spine and centrum of anterior caudal.....	.108
Transverse diameter of neural spine " " at base....	.0235
Antero-post. diam. four anterior caudal neural spines in contact..	.069
Length centrum of a dorsal.....	.04
Vertical diameter " "0615
Transverse " " " (crushed).....	.041

These remains were found in place by Prof. B. F. Mudge: he states that their extent was eight feet. As they embrace no cervical vertebræ nor portions of cranium, two feet are probably to be added, giving a total of near ten feet for the length of this fish. It was discovered at a point on the bank of the Solomon's or Nepaholla river, in Kansas, 160 miles from its point of junction with the Kansas river.

SAURODON Hays.

Transac. Amer. Philosoph. Society, 1830, 476.

SAURODON LEANUS, Hays.

Loc. cit. Tab. xvi. Leidy Trans. Am. Philos. Soc. 1856.

From the cretaceous green sand of New Jersey.

ICHTHYODECTES. Cope, *gen. nov.*

In this genus the teeth are subcylindric and slender, without cutting edges. The inner margins of the maxillary and dentary bone exhibit no dental foramina, which are in *Saurocephalus* and *Saurodon*, of large size.

ICHTHYODECTES CTENODON. Cope, *sp. nov.*

This species is established on one complete maxillary bone, and three-fourths of the other, a large part of the dentary bone, with the entire dental series; numerous portions of cranial bones, with thirteen vertebræ. These, according to Prof. Mudge, were found together, and to all appearance belong to the same animal.

The dental characters differ from those of *Saurocephalus*, as above pointed out, and in this species more than in *S. leanus*. The crowns of the teeth are more exserted and slender. The inner face of the crown is more convex than the outer; but there is no angle separating the two aspects. The apex is moderately acute, and directed a little inwards, owing to a slight convexity of the external face. Enamel smooth. The alveoli are very close together, and are probably only separated in their deeper portions. There are forty-two teeth and alveoli in the maxillary bone. The palatine condyle is low, and its anterior border falls opposite to the last tooth, or the indented surface which was occupied by the premaxillary bone. The more proximal part of the maxillary curves inwards and backwards behind the position of the premaxillary more than in *S. prognathus*. The maxillary is a rather thin and narrow bone, with a

broad obtuse and thinned extremity. Its superior margin is marked with one or more acute ridges, which look as though it had a contact with a large preorbital bone. Two fractured bones with an elongate reniform condyle on a wide peduncle, look like the articular extremity of an operculum, which view is confirmed by their application to some flat, coarsely rugose bones which resemble parts of the latter.

The dentary bone is remarkable for its straightness and laminar character, and for the depth of the symphysis. The length of the latter is preserved, while posteriorly to it the lower margin of the dentary is broken away. The alveolar margin is slightly concave, and unites with the symphyseal at an angle of 65°. There are twenty-seven teeth and alveolæ, which grow a little larger to the posterior extremity of the series; anteriorly the alveoli are confluent externally, but posteriorly the septa are frequently complete, though thin. In neither this bone nor the maxillary are to be found the foramina along the bases of the teeth, characteristic of *Saurocephalus* or *Saurodon leanus*, as pointed out by Harlan and Hays. The vertebræ form a series of 13.4 inches in length, embracing thirteen caudals. This is indicated by the close approximation of the inferior pits and inserted pleurapophyses, and absence of lateral grooves. There are important differences from what has been described as characteristic of *Saurocephalus*. The neural arches, whose bases only are preserved, are much lighter and narrower than in it, and its sutural union with the centrum is less distinct. Their bases issue from pits; but their anterior portions appear in some cases at least to be co-ossified. They exhibit a longitudinal rib near one side. There are no heavy neural spines preserved. The sides of the centra are longitudinally rugose striate; inferiorly they are rugose with exostoses.

<i>Measurements.</i>	<i>M.</i>
Length maxillary bone	0.158
Depth at condyle.....	.031
“ “ extremity.....	.023
Length crown of a tooth.....	.0061
Diameter crown at base.....	.0038
Length alveolar border of dentary.....	.106
Depth symphysis “ “047
Length opercular condyle.....	.018
Length centrum anterior caudal.....	.024
Width “ (crushed).....	.0278
Depth “ “047

Specimens from six miles south of Sheridan, Kansas, on the north fork of the Smoky Hill river near its mouth.

GENERAL CONSIDERATIONS.

There have been described above, remains of three species, which include jaws with teeth, and associated vertebræ. In two of these cases the jaws and teeth were found together; in the third they came in the

same small box without special indication of locality; but the vertebræ are of precisely the same size sculpture, mineralization, and color as a large series whose locality is exactly known, to which they probably belong. Moreover, the jaws and vertebræ bear the same relation of size to each other in all three series. These facts render it highly probable that the remains are in each case rightly referred to the same animal. That no mixture has occurred is also probable from the fact that the large and small series (*Ichthyodectes* and *S. prognathus*) came from the same locality (Sheridan), while the species of intermediate size was discovered 160 miles from the mouth of the Solomon river, a long distance off. The pectoral spine, accompanying and belonging to the *S. prognathus*, I have shown to be the same as the *Xiphactinus* of Leidy, but probably not of the species *X. audax*.

The fourth series described above as *S. thaumas* exhibits precisely the vertebral characters of the two other species of *Saurocephalus*, and I cannot resist the evidence that it belongs to that genus or the same family. Its remains pertain to one animal, as asserted by Prof. Mudge, and their color and condition, coated with a chalky deposit of a ferruginous yellow color, lends great probability to the statement, to say nothing of more important reasons. No remains of pectoral spine are preserved; but instead, the remarkable segmented ray described. This comes from the posterior region of the vertebral column, and is, I believe, an anal spine, or the adjacent rays or compound ray forming the margin of the caudal fin. This finds support in the analogous structures already mentioned as occurring among Siluroids, etc., and the resemblance of the pectoral spine to the same weapon of the same group adds to the probability of the correctness of this conclusion.

These remarks are made because Prof. Agassiz, in the *Poissons Fossiles*, has referred several spines to the *Cestracant* genus, *Ptychodus*, which are very similar in character to that described above as the anal or caudal support of *Saurocephalus thaumas*. These were derived from the upper cretaceous chalk of Kent, England, where *Ptychodus* teeth also occur. The *Saurocephalus* teeth, described by Prof. Agassiz in the same work, were, however, derived from the same chalk and the same locality, and, from what has preceded, I believe the segmented spines should be referred to the latter genus rather than to *Ptychodus*. This is the more probable, in view of the fact that Prof. Mudge did not procure a single *Ptychodus* tooth during his exploration.

ON THE FISHES OF A FRESH WATER TERTIARY IN IDAHO, DISCOVERED BY CAPT. CLARENCE KING.

By E. D. COPE.

The materials on which the present account is based were placed in my hands by the Smithsonian Institution. They were obtained by Capt. Clarence King, on his expedition sent out by the Government, for the geological exploration of the fortieth parallel west of the Mississippi river.